2018 Landing Site Selection

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and the ExoMars LSSWG (WG composition in presentation)

MEPAG#30
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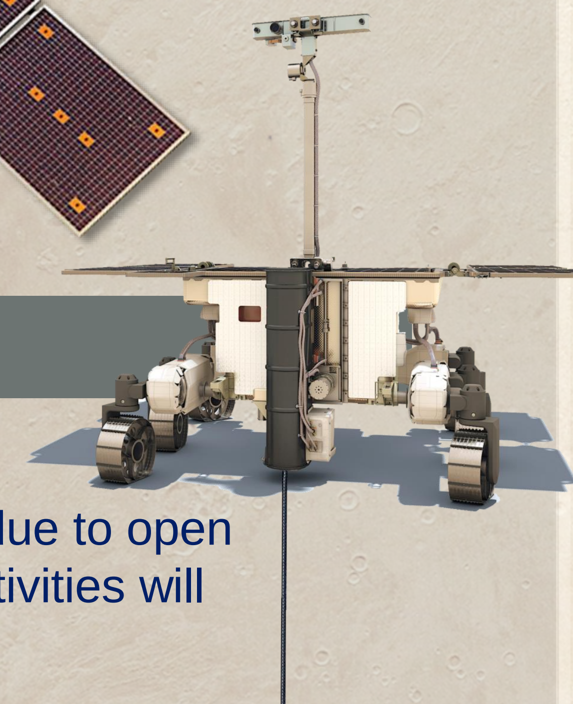
ExoMars 2016

- **Critical Design Review (CDR):**

  The ExoMars 2016 CDR Closure Board was successfully held in 16 April 2014, with some actions.

  A new orbit (more adequate for imaging) has been selected for the TGO. The new orbit complies with Planetary Protection orbital lifetime requirements.



ExoMars 2018

- **System - Preliminary Design Review (S-PDR):**

  The ExoMars 2018 S-PDR started in Q4 2014. Not all objectives have been achieved due to open points still to be resolved in the Descent Module (DM) design. The S-PDR close-out activities will continue until early May 2015 to address the remaining issues.

- **NASA Contributions:**

  The NASA contribution to the MOMA instrument, the Mass Spectrometer (MS) and electronics recently completed their CDR. Flight hardware is being built. The two Electra radio transceiver flight models (for TGO to Mars surface communications) have been delivered to Industry by NASA.

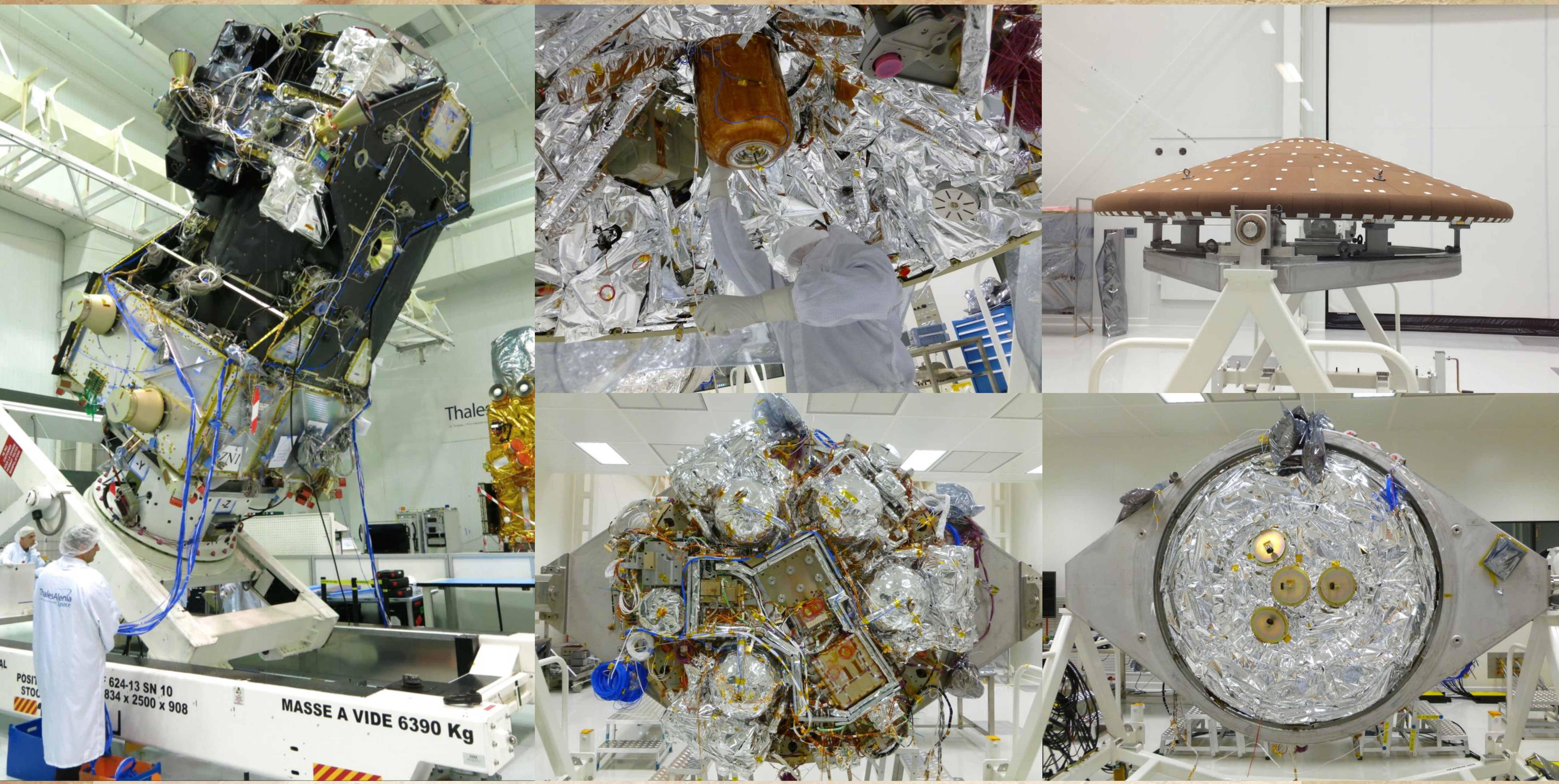
- **Landing Site Selection (LSS) Progress:**

  The second LSS workshop was held in December 2014 —four candidate sites remain under consideration.

Credit: Mamers Valles, MEX/HRSC

ExoMars 2016 Flight Hardware

E X O M A R S



- **Making good progress toward a Jan 2016 launch:**
  - The TGO Flight Model (FM) being assembled at TAS-F, Cannes (FRA).
  - The EDM FM at TAS-I, Torino (ITA).

Credit: Mamers Valles, MEX/HRSC

Landing Site Selection

Identify a suitable landing site for the ExoMars 2018 mission:

- **Scientifically compelling** —high probability of achieving the science objectives.
- **Safe for landing** —no safe landing, no science.
- **Safe for surface operations** —energy generation, locomotion, etc.
- **Planetary Protection** —no landing on or access to Mars special regions.

Credit: Argyre Planitia, MEX/HRSC

The Rover and Surface Platform

LSSWG

E X O M A R S

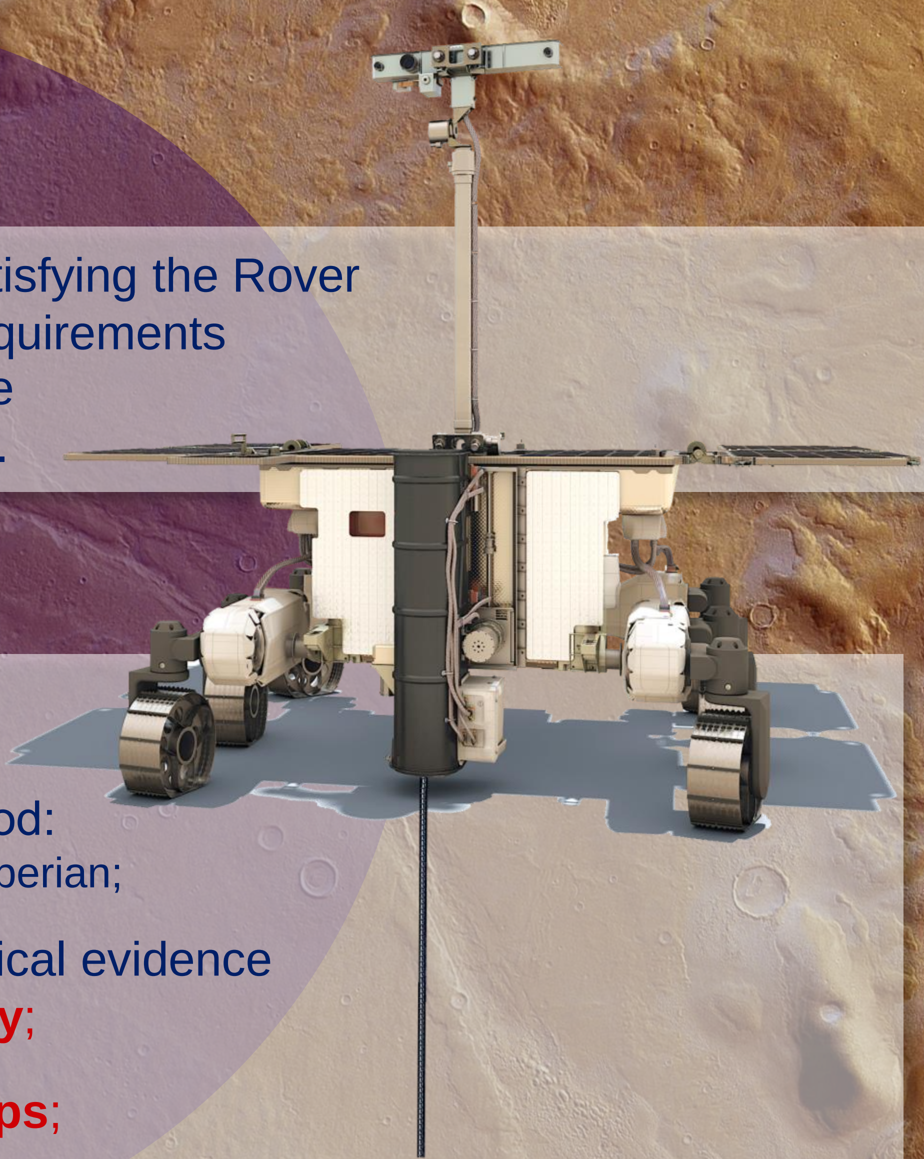
#	Name		Expertise	Country
1	Frances Westall	CNRS-Orléans	BIOSIGNATURES/ESWT/PPWG: Preservation, ancient geology	FR
2	Howell Edwards	Bradford U.	BIOSIGNATURES: Preservation, mineralogy, Raman	UK
3	Lyle Whyte	McGill	BIOSIGNATURES: Arctic microbiology, cold drilling	CAN
4	Alberto Fairén	CAB	BIOSIGNATURES: Mars hydrogeology and biosignatures	E
5	Jean-Pierre Bibring	IAS	GEOLOGY/ESWT: Hydrated minerals, Mars history	FR
6	John Bridges	U. of Leicester	GEOLOGY: LS mapping, topography	UK
7	Ernst Hauber	DLR	GEOLOGY/PPWG: Topography, layered deposits, alluvial fans	DE
8	Gian Gabriele Ori	IRSPS	GEOLOGY: Sedimentary geology, mapping	ITA
9	Stephanie Werner	U. Oslo	GEOLOGY: Dating, mineralogy, resurfacing processes	NO
10	Damien Loizeau	U. Lyon	GEOLOGY: Dating, geomorphology, mineralogy	FR
11	Ruslan Kuzmin	IKI	GEOLOGY: Ice/water processes	RUS
12	Becky Williams	PSI	GEOLOGY: Fluvial geomorphology and sedimentary processes	USA
13	Jessica Flahaut	VUAmsterdam	GEOLOGY: Mineralogy, layered deposits, mapping	NL
14	François Forget	LMD	ATMOSPHERICS: Atmospheric Modelling	FR
15	Jorge L. Vago	ESA	SCIENCE: ExoMars Project Scientist	ESA
16	Daniel Rodionov	IKI	SCIENCE: ExoMars Project Scientist	RUS
17	Oleg Korablev	IKI	SCIENCE/ESWT: IR mineralogy and atmospheric aerosols	RUS
18	Håkan Svedhem	ESA	SCIENCE: TGO Project Scientist	ESA
19	Gerhard Kminek	ESA	SCIENCE/PPWG: Planetary Protection, organics degradation	ESA
20	Leila Lorenzoni	ESA	PROJECT: ExoMars EDL and landing site engineer	ESA
21	Olivier Bayle	ESA	PROJECT: ExoMars EDM systems engineer	ESA
22	Luc Joudrier	ESA	PROJECT: ExoMars Rover GNC and operations engineer	ESA
23	Silvia Bayón	ESA	PROJECT: ExoMars spacecraft composite systems engineer	ESA
24	Michael Khan	ESA	PROJECT: ExoMars mission analyst at ESOC	ESA
25	Viktor Mikhaylov	TsNIIMASH	PROJECT: ExoMars EDL & ground testing manager	RUS
26	Alexander Zashirinsky	Lavochkin	INDUSTRY: ExoMars EDL engineer	RUS
27	Sergey Alexashkin	Lavochkin	INDUSTRY: ExoMars DM Chief Designer	RUS
28	Fabio Calantropio	TAS-I	INDUSTRY: ExoMars EDL engineer	ITA
29	Andrea Merlo	TAS-I	INDUSTRY: ExoMars Rover GNC engineer	ITA

Credit: Mamers Valles, MEX/HRSC

Science Requirements

EXOMARS

- A landing site satisfying the Rover search-for-life requirements also works for the Surface Platform.



1. The site must be **ancient** —from Mars' early, habitable period:
   Pre- to late-Noachian (Phyllosian), possibly extending into the Hesperian;

1. The site must show abundant morphological and mineralogical evidence for long-duration, or frequently reoccurring **aqueous activity**;

3. The site must include numerous **sedimentary rock outcrops**;

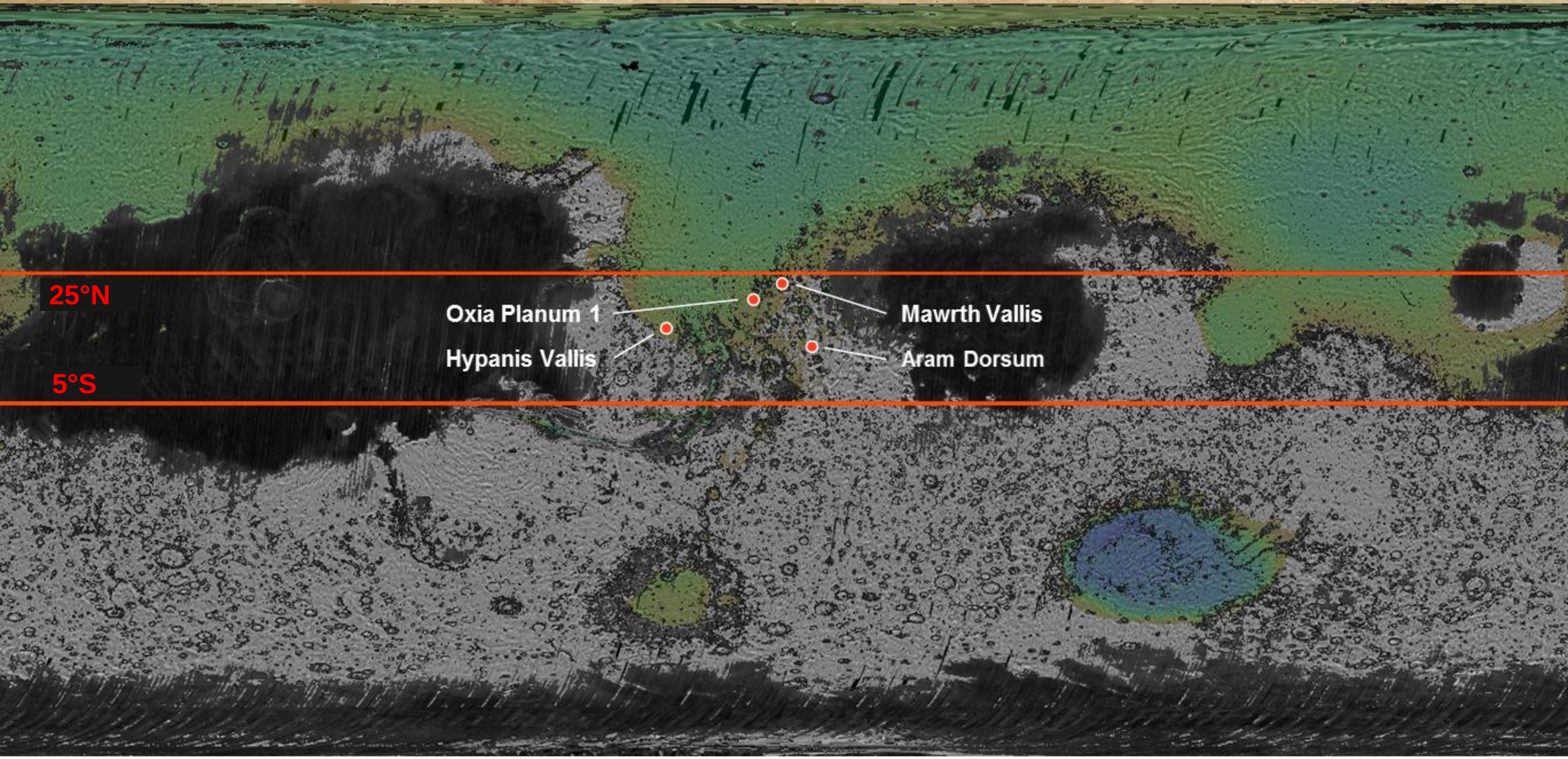
4. Outcrops must be **distributed** over the ellipse to ensure the rover can get to some of them.

5. The site must have **little dust** coverage.

Credit: Reul vallis, MEX/HRSC

Candidate Landing Sites

E X O M A R S



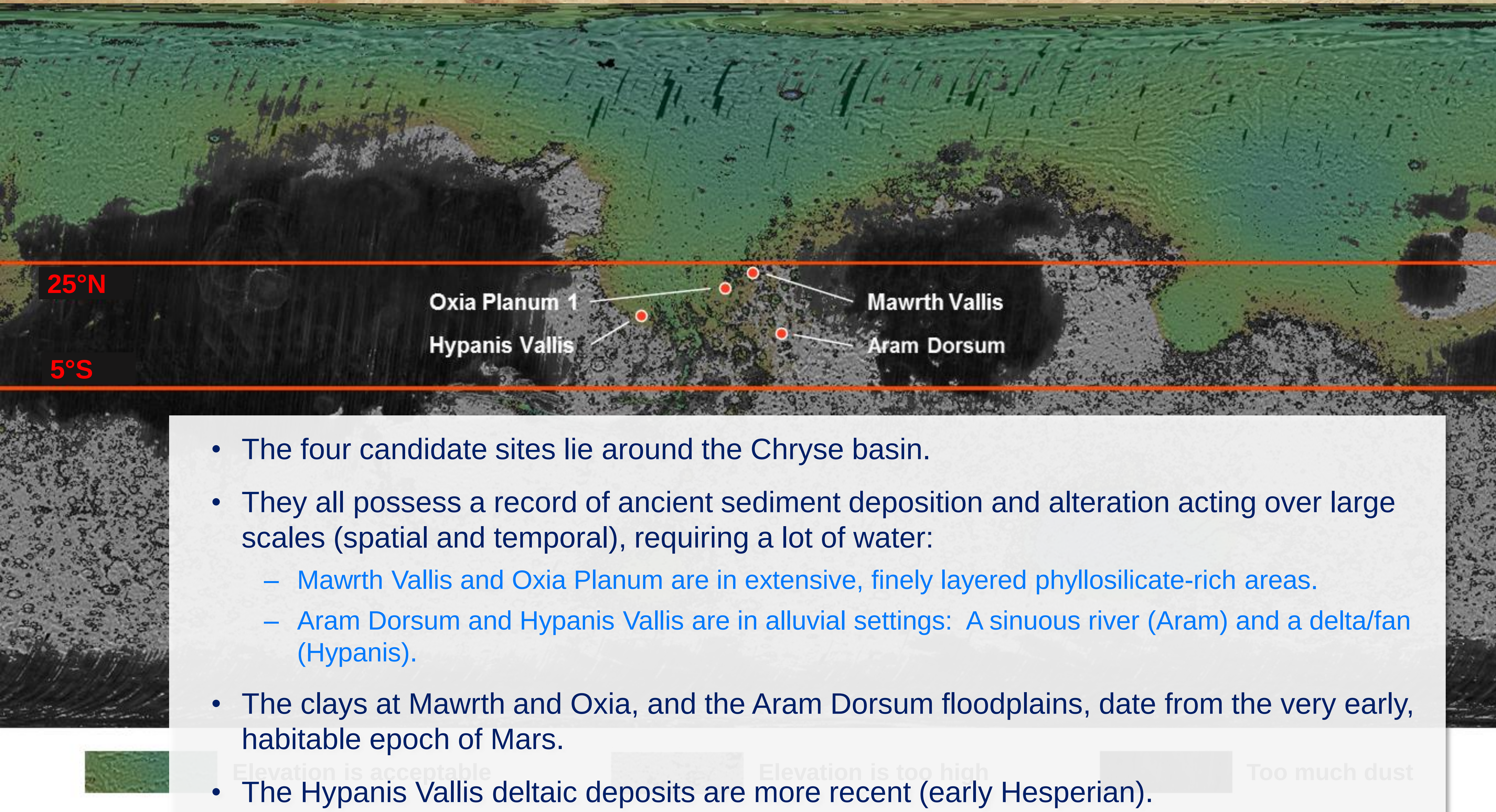
Elevation is acceptable

Elevation is too high

Too much dust

Credit: Mamers Valles, MEX/HRSC

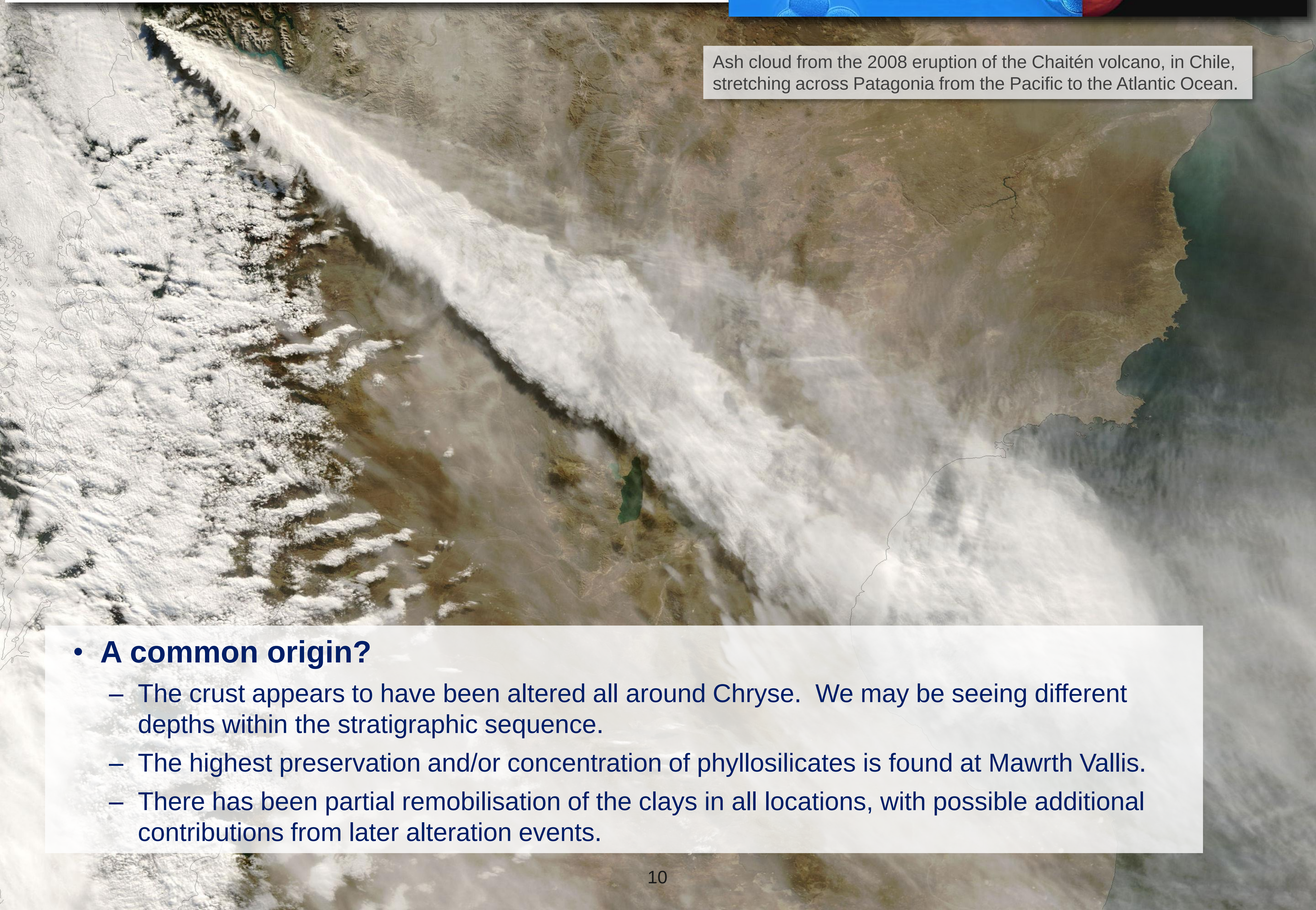
Candidate Landing Sites



- The four candidate sites lie around the Chryse basin.
- They all possess a record of ancient sediment deposition and alteration acting over large scales (spatial and temporal), requiring a lot of water:
  - Mawrth Vallis and Oxia Planum are in extensive, finely layered phyllosilicate-rich areas.
  - Aram Dorsum and Hypanis Vallis are in alluvial settings: A sinuous river (Aram) and a delta/fan (Hypanis).
- The clays at Mawrth and Oxia, and the Aram Dorsum floodplains, date from the very early, habitable epoch of Mars.
- The Hypanis Vallis deltaic deposits are more recent (early Hesperian).
- Outcrops and scientific targets are well distributed in the landing ellipses and therefore accessible.

Credit: Mamers Valles, MEX/HRSC

Clays All Around Chryse



Ash cloud from the 2008 eruption of the Chaitén volcano, in Chile, stretching across Patagonia from the Pacific to the Atlantic Ocean.

- **A common origin?**
  - The crust appears to have been altered all around Chryse. We may be seeing different depths within the stratigraphic sequence.
  - The highest preservation and/or concentration of phyllosilicates is found at Mawrth Vallis.
  - There has been partial remobilisation of the clays in all locations, with possible additional contributions from later alteration events.

Clays All Around Chryse

E X O M A R S

Ash cloud from the 2008 eruption of the Chaitén volcano, in Chile, stretching across Patagonia from the Pacific to the Atlantic Ocean.

- **Formation mechanism ?**
  - The large lateral extension of the deposits (reaching 100’s of km),
  - Their finely laminated structure,
  - Their composition and ancient age (from a time when volcanism was widespread),

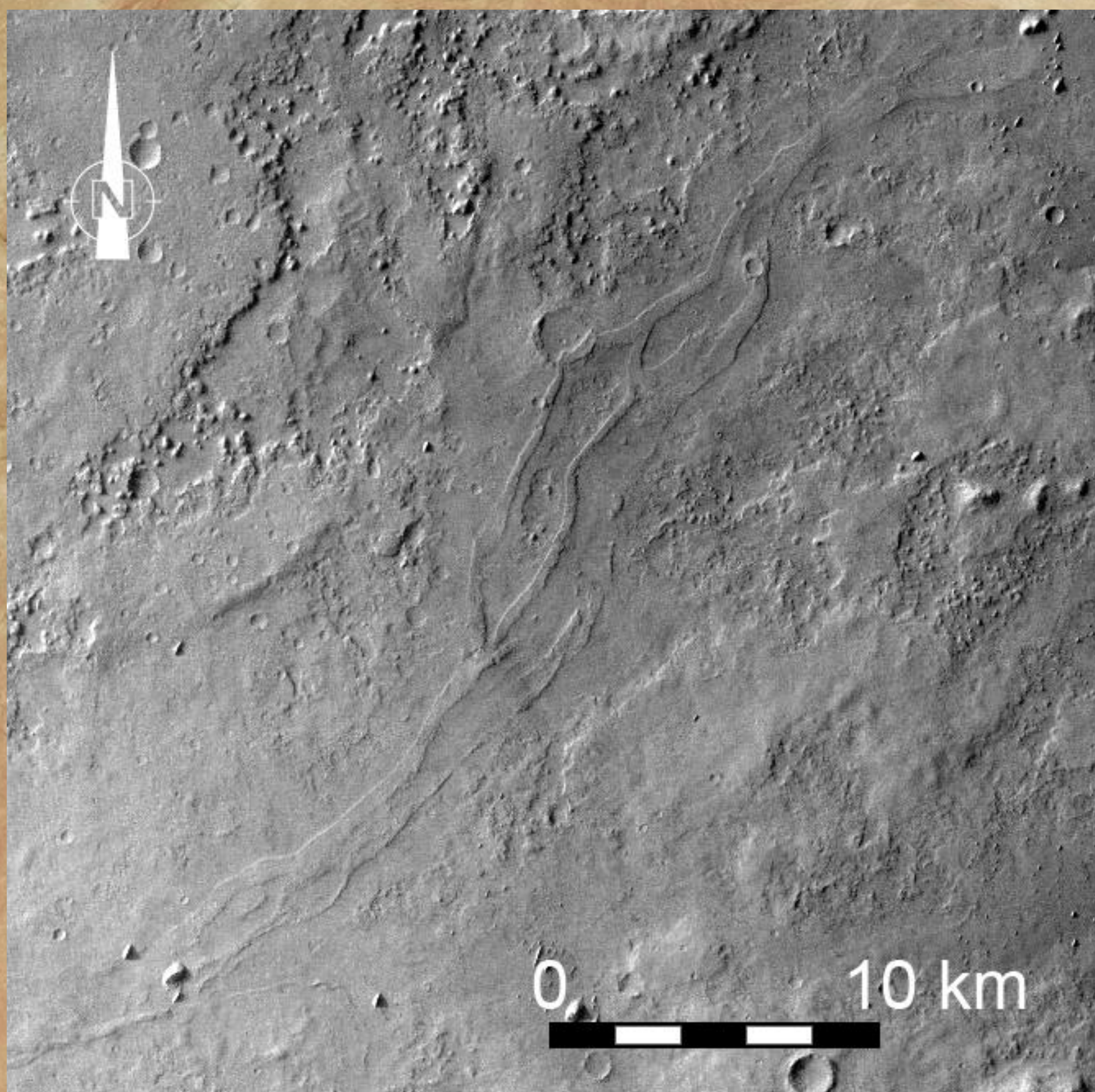
  suggest that the deposition (and wetting) of layers of pyroclastic material may have been involved in the formation of the first deposits.

  - Subsequent alteration and weathering (top down leaching, and possibly bottom up in places) may have further modified the mineral composition (e.g. Al-rich clays on top).
  - Erosion and transport (water & wind) may have affected some places more than others.
    Maybe the top Al-rich clays were removed from some areas, but were better protected in others—e.g. Mawrth Vallis?

Depositional Environments

Fluvial

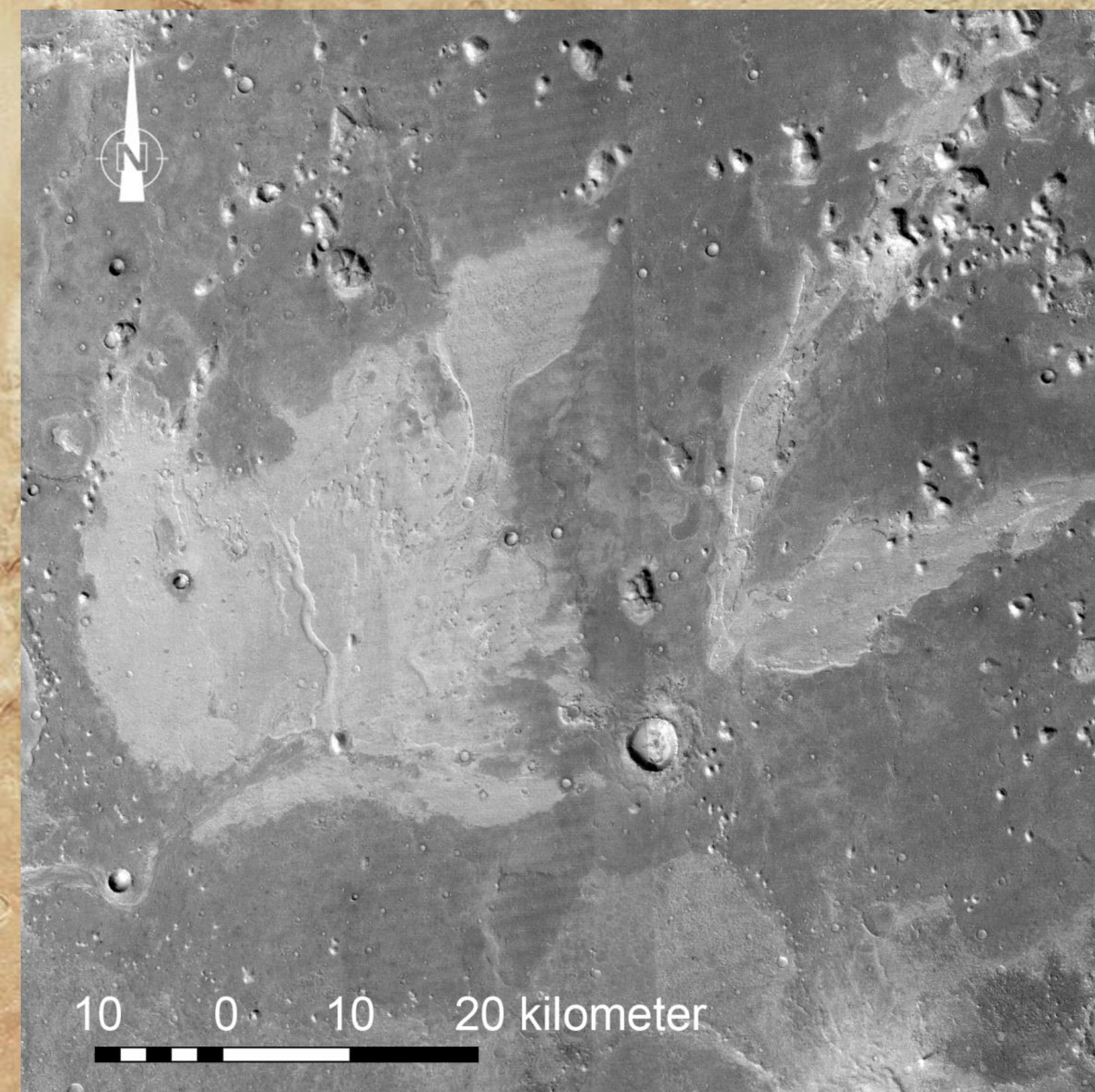
Aram Dorsum
inverted channels



Channels as topographic high-standing ridges
→ relief inversion

Deltaic or Alluvial Fan

Distal Hypanis Vallis
fan-shaped deposits



Light-toned, fine-grained layered deposits

Credit: Mamers Valles, MEX/HRSC

Recent Findings

EXOMARS

- Aram Dorsum:
  The alluvial sediments are probably older than previously thought (~4.0 Ga). Polygonal fractures can be found at the bottom of pits. The proposing team has performed a very useful analysis of how far primary target material would be from any touchdown point within the ellipse if the rover could travel 1 km, 2 km, etc.
- Oxia Planum:
  This site includes very old terrain (~4.0 Ga) that was buried and exhumed. The phyllosilicates are located at the lowest points (basins?). A vermiculite spectral signature dominates the phyllosilicate signatures in Oxia. Vermiculite can be formed by weathering or hydrothermal alteration of some minerals in the mica family of phyllosilicates, such as biotite or phlogopite. The proposing team has suggested that perhaps these phyllosilicates form the base of the sequence observed in Mawrth Vallis.
- Mawrth Vallis:
  Ancient terrains having roughly the same age as those in Oxia (~4.0 Ga). The proposing team has presented an interesting analysis of potential Earth analogues. They concluded that the palaeosols at John Day Fossil Bed National Monument, Oregon (USA) seem to provide a good match for the orbital observations. These phyllosilicate-rich deposits are interpreted to be the result of pedogenetic alteration of volcanic ash layers hydrated by fluvial or alluvial flows.
- Hypanis Vallis:
  The distal, fine-grained deltaic deposits that constitute the primary target are more recent than those at the other sites (~3.5 Ga). Some instances of Mg-Fe phyllosilicate signatures have been detected near the rim of Majong crater (in the ellipse) and in outcrops of the delta/fan (near the ellipse).

Credit: Hebes Chasma, MEX/HRSC

Conclusions so far

E X O M A R S

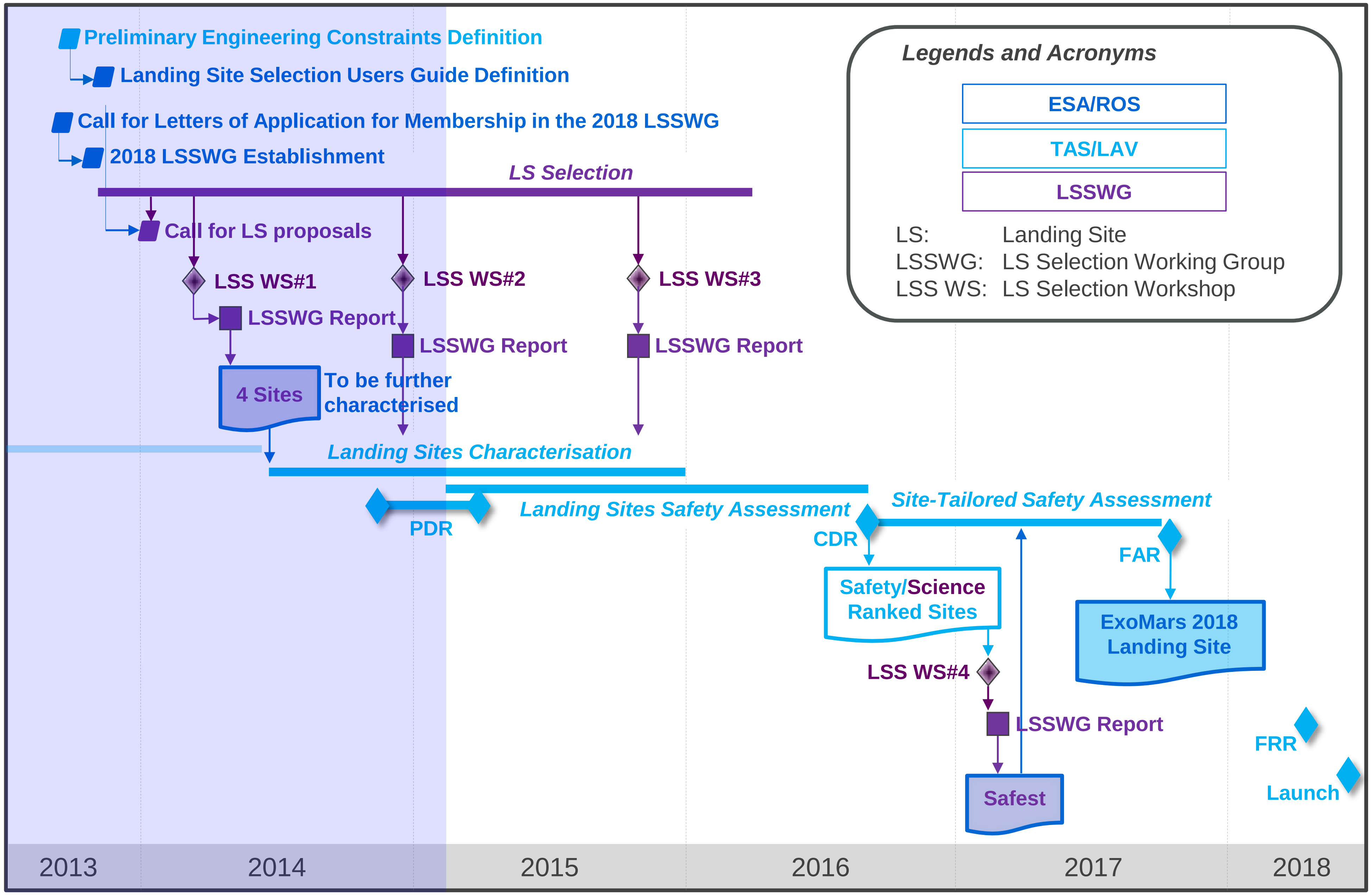
Life everywhere ???

- Based on what we know so far, any of the four candidate landing sites could have been inhabited by microorganisms.
- At the time when the layered clays were deposited in Mawrth and Oxia, Mars was probably habitable (denser atmosphere, more surface water, more volcanic and hydrothermal activity). The Aram deposits are also ancient.
- It is likely that by the time the Hypanis deposits were emplaced, the situation had started to change. However, it was still possible to have surface water and transport of sediments.
- How likely is it that we can land on, or easily access an interesting location with many suitable outcrops?

Credit: Hebes Chasma, MEX/HRSC

LSS Process

E X O M A R S



- The Project Team has recently proposed to use Oxia Planum as a Reference Site to demonstrate the landing site certification process for the mission Critical Design Review (CDR), planned to take place in mid 2016. The Project Team would then extend this process to other site(s) based on the LSSWG recommendation.
- The LSSWG is considering this proposal.